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The PRESIDENT.—The Society must appreciate highly any communication upon physical geography from so eminent an authority as Sir John Herschel. On this occasion he shows that this projection presents a more accurate representation of the world in one sphere than any other stereographic projection. It is not only more accurate than that of Mercator, but is, he suggests, more correct than the ingenious projection prepared by our associate Col. James, with which you may now compare it.

(The diagrams prepared by Sir John Herschel and those of Col. James were then exhibited to the Meeting.)

The Third Paper read was :—

3. *Remarks on the Isthmus of Suez, with Special Reference to the proposed Canal.* By COMMANDER BEDFORD PIM, R.N., F.R.G.S.

DURING a visit to Egypt in December last, my attention was forcibly drawn to a subject that has for the past few years engaged a considerable amount of public interest—the cutting a canal across the Isthmus of Suez.

While in Cairo I had the advantage of making the acquaintance of gentlemen well qualified, both from local and professional knowledge, to form a dispassionate opinion on this much-vexed question, and I now propose to review the subject in its various bearings, so as to enable the Society to form an independent judgment of its merits.

I shall begin with describing the geographical position and physical features of the country, then detail the attempts of the Ancients at canalization, and conclude with a narration of the various plans and projects which have been proposed in modern times.

Egypt, of which the Isthmus of Suez is a component part, lies between the 29th and 33rd degrees of E. long., and in both these meridians is bounded by sandy deserts. On the north is the Mediterranean, in the 31st parallel of north latitude, while to the south of parallel 23° is the boundary line. On the south-east the waters of the Red Sea wash the coast and form the roadstead of Suez, whence to Pelusium, namely the “Isthmus,” the distance is only 65 geographical or 74 statute miles; Suez being situated in 29° 58' 37" N. lat., Tineh, the ancient Pelusium, in 31° 3' 37" N. lat.

The northern or Mediterranean coast presents a barren appearance, and consists of low sandy hillocks and swamps. Excepting Alexandria, no sort of harbour for vessels of any size exists. The water in the vicinity of the land is shallow, the bottom shelving very gradually towards the beach, especially so in the Bay of Tineh or Pelusium, where the depth of 25 feet averages a distance

from the shore of more than 3 miles. The current has a constant easterly set, the velocity of which is much influenced by the strength of the wind. The tides have a very inconsiderable rise and fall, and are more or less dependent on the winds; the maximum height ever recorded being only 2 feet 8 inches.

The prevailing winds are westerly and north-westerly in July, August, and September, and continue to blow very much in the same direction, with the exception of an occasional gale from the south-west, until March; the southerly winds then prevail until June, during which month easterly winds with thick weather and northers at night may be expected. Thus, during the greater part of the year westerly and north-westerly winds cause a constant swell and surf to roll into the exposed Bay of Pelusium, which is open to sixteen points of the compass; and, when to this is added the extreme lowness of the coast, without a single feature by which any part can be recognized, some idea may be formed of the difficulty and danger of the navigation.

The south-east or Red Sea coast-line is also extremely arid and sandy, but unlike the Mediterranean shores, which are flat, parts of it, such as Gebel Awebel and Gebel Attaka, may be called mountainous. In the immediate vicinity of Suez the land is low, and the roadstead encumbered with shoals and sandbanks, the latter of considerable extent, jutting far into the sea, and susceptible of movement in heavy winds.

The harbour of Suez is only accessible to the small native coasters, and even the roadstead has only a depth of 25 feet at about 3 miles from the quay. The currents in the Red Sea are influenced by the winds, and according to their strength attain a velocity of from 15 to 20 miles in the 24 hours. The tides have a much greater rise and fall than in the Mediterranean, the maximum height being 7 feet 2 inches, and the minimum observed 2 feet, showing a difference of 4 feet 6 inches between the highest tide of the Mediterranean and that of the Red Sea. The prevailing winds from March to November are northerly, but during the remaining three months, December, January, and February, southerly winds blow, though by no means steadily. This law is subject to some variation down to the Red Sea, but as a general rule it holds good as far as the straits of Babel Mandeb. The Red Sea runs about north-west and south-east 1308 miles from Suez to Aden, with a varying breadth of from 30 to 200 miles. The navigation is rendered very unsafe by the numerous rocks, shoals, and coral banks which fringe the shore on either side, but the centre is deep and free from any dangers; this has been abundantly proved by the steamers of the Peninsular and Oriental

Company, which have navigated that part of the sea for many years without accident. On the other hand, sailing ships beating against the northerly wind are obliged to approach the shore on either side, and often become hopelessly involved in the perils just alluded to: in fact, the average loss of shipping during the last year was 1 in 10—not clumsy colliers, but fine ships, English and American, some of them upwards of 1000 tons.

Of 12 vessels which have lately reached the port of Suez from Aden, the average passage has been 52 days, which is rapid to what it used to be, and is the result of employing first-class ships. The passages from England to Alexandria and from Aden to Suez are the most tedious in the world; the first averages 55 miles per day, the latter 25 miles, while other ocean routes average 100; therefore, in making a comparison, the distance between England and Egypt must be multiplied by 2 at least, and between Suez and Aden by 4. Thus it is certain that neither in the Red Sea nor the Mediterranean navigation can safety or certainty of passage be looked for by sailing ships, and the captain of a merchant ship would think twice before he adopted such a route.

The physical features of Egypt are unique; it has been well named the "River Land." In its pristine state it was doubtless a complete desert, but the Nile, overtopping its banks, flooded the sandy surface, and, depositing its rich alluvium, soon reclaimed by its fertilizing effect a large portion of the adjacent wilderness.

The Nile has a total length of 1320 miles from source to mouth, but taking the windings into consideration it is nearly twice as long—viz. 2240 miles. The depth is most irregular: 50, 60, and even 70 feet often occur; but shoals, stretching from bank to bank, and having only 2 or 3 feet water on them, are frequently met with, so that the river is not navigable for vessels larger than our Thames boats. At nearly 100 miles from the sea the waters divide into the Damietta and Rosetta branches, and form the far-famed Delta, which is an immense triangular plain, well cultivated by means of a most elaborate and pains-taking system of irrigation. It has been calculated that the Nile valley, as far as the apex of the Delta, averages a breadth of about 7 miles; namely, in the widest part 10 or 11, and in the narrowest 2 miles across, being, as already observed, entirely due to the alluvium deposited at each high Nile to the depth of 0.004 inches, and which, according to Reynault, in his '*Mémoires sur l'Égypte*,' contains 11 water, 9 carbon, 6 oxide of iron, 4 silica, 4 carbonate of magnesia, 18 carbonate of lime, 48 alumina = 100.

Besides the amount of alluvium deposited, millions of tons are

annually discharged into the Mediterranean, and meet an east-going current which carries the mass towards the Bay of Pelusium. The effect of this mud-carrying current would be to silt up any harbour or channel which came in its way. A striking instance of the quantity of mud discharged by the Nile is related in Dr. Clarke's 'Travels.' He says:—

"July 16th.—This day, being Sunday, we accompanied Captain Culverhouse, H.M.S. *Romulus*, to the gun-room, to dine with his officers, according to his weekly custom; as we were sitting down to dinner the voice of a sailor employed in heaving the lead was suddenly heard calling 'half four.' The captain starting up reached the deck in an instant, and almost as quickly putting the ship in stays she went about. Every seaman on board thought she would be stranded. As she came about, the surface of the water exhibited a thick black mud. This extended so widely that the appearance resembled an island, at the same time no land was really visible, not even from the mast-head, nor was there any notice of such a shallow in any chart on board. The fact is (as we learnt afterwards) that a stream of mud, extending for many leagues off the mouths of the Nile, exists in a moveable deposit on the coast of Egypt."

During the periodical overflow of the Nile, its waters attain in Upper Egypt the height of from 30 to 35 feet; at Cairo about 23 feet; and in the northern part of the Delta only 4 feet. It begins to rise at Cairo about the beginning of July, increases during 100 days till the middle of October, then subsides, and arrives at its lowest point near the end of April. During the period of inundation the current is very powerful, so much so that fresh water may be skimmed off the surface two or three miles at sea. The average force of the current throughout the year may be considered $2\frac{1}{2}$ miles per hour. The minimum discharge has been estimated at 54,000,000 cubic feet of water per hour. The amount of alluvium deposit is 0.004 inches. At the mouth of both the Damietta and Rosetta branches there is a bar in the form of a horse-shoe, with an average depth of 5 feet water. During high Nile the great velocity of the stream drives this bar some distance to seaward, but, as the strength of the current diminishes, it returns to its original position in the old form.

The entire supply of sweet water for the whole of Egypt is derived from the Nile; there are wells, it is true, dug in the sands, but the water they contain is generally salt, and even under the most favourable circumstances brackish.

The stratification of Lower Egypt belongs entirely to the tertiary formation.

The eastern longitudinal Talus of the Libyan Desert, forming the western boundary line of the Nile Valley, is composed of parallel layers of more or less argillaceous and arenaceous limestone, alternating with beds of shale of variable thickness, the dryness of the soil imparting hardness to the layers of clay. On the eastern side of the valley, the part we have to do with, the surface consists of loose sand. Sand-hills of some height frequently occur, and the sand on these hills is so extremely fine that it is put in motion by a very slight wind, and wells 7 or 8 feet deep are filled up in one storm. The highest part of the isthmus is about 40 feet, and is near the Bitter Lake Basin, which is 37 feet below the level of the sea. There are several depressions covered with salt, into one of which (that is to say Lake Timsah) the Nile during inundations sometimes finds its way. The basin of Lake Timsah is 2 feet below the level of the Red Sea.

To the northward nothing but flat sand-plains present themselves as far as Lake Mensalah, which bears the character of a quicksand, and, consequently, is dangerous to travel near. Below the surface of the isthmus, at a mean depth of 13 feet, water is met with, and most probably the subsoil would partake very much of the "quick" character of Lake Mensalah.

Such a soil as that just described would be difficult enough to excavate, the sand having a tendency to fall in as fast as thrown out; and when the watery subsoil is reached, how much greater would be the difficulty!—in fact it is problematical if a cutting could be made at all. Then, as regards Lake Mensalah, no one can tell to what depth the walls must be sunk before the excavations could be commenced.

It would seem that when Egypt (780 B.C.) had attained a maritime supremacy, and its commerce began to extend to Arabia and India, the project naturally arose of opening out an easy mode of access to the Nile by means of a canal connecting that river with the Red Sea. According to Strabo, Pliny, and Aristotle, the attempt to cut a canal to the Red Sea was first made by Sesostris, about the time of the Trojan war, B.C. 1184. This canal, however, appears to have been intended for irrigating purposes only. Herodotus informs us that the work was commenced in the reign of Nico, B.C. 600, who failed to accomplish his object in consequence of being warned against it by an oracle. The next attempt was made during the Persian occupation by Darius, who is said to have cut from the Bitter Lakes to the sea, but no account can be found of the opening of this canal; indeed Aristotle asserts that the work was stopped in consequence of the different level of the Red Sea.

Ptolemy Philadelphus, B.C. 254, has the credit of completing this great undertaking; but I am of opinion, after a careful examination of the ground, that it was not by cutting a canal, but rather by the construction of a good road, the remains of which are very distinct, and over which, no doubt, the "ships of the Desert," as the camels are called in the Arabian language, passed to and fro. The ambiguity of this phrase has most probably led to the belief of a ship-canal through the Desert—a mistake easily made by writers who depended on the *vivâ voce* statements of the natives. The Caliph Omar removed the point of junction from Bubastis, higher up the Nile, by which means he obtained 6 feet more rise, and, consequently, the navigation of the canal was much prolonged; before that time it had only been navigable two months in the year.

Besides the usefulness of this canal as a means of transit, vast tracts of desert were reclaimed by its fertilising influence, and flourishing cities sprung up on its banks and decayed on its disappearance, the ruins of which are still to be seen. Its original course was as follows:—Commencing at Bubastis, on the Pelusiac or eastern arm of the Nile, now completely filled up, it was conducted to Lake Timsah on the Crocodile Lakes, and thence to the Bitter Lakes, where, as I said before, I suspect the canal ended. The cutting was altogether about 60 miles, averaging a breadth of 150 feet and a depth of 20 feet.

This circuitous communication was probably preferred both for local and political reasons, but, unfortunately, there is no information regarding the effect this great undertaking produced on the commercial prosperity of the country. Under the Romans it was little used, but the Saracens found it of importance in their communication with Mecca. It is probable that the great amount of time and labour required to keep the canal in working order, and the fact that, in practice, the primitive mode of transit by caravan was cheaper and better adapted to the requirements of the country, were the reasons it so repeatedly fell into disuse. With some little trouble the extent and direction of both road and canal can still be made out.

I have now given as brief an account as possible of the geographical and physical features of Lower Egypt, and the attempts made by the ancients to unite the Mediterranean and Red Sea. Certainly, both natural causes and the antecedents of the country seem to sound a note of warning against the idea of canalization. Indeed, the geographical position of the isthmus, its exposed and dangerous northern coast, as well as barren and impracticable soil, offer obstacles of so grave a nature to the successful accomplishment

of such a project that, if ever carried out, the other marvels of Egypt would dwindle into insignificance before it.

Every one must be struck with the grandeur of the idea of dividing two continents so as to enable large ships to proceed direct from the ports of Europe to ports of the East. The realization of such an idea would certainly be quite in accordance with the spirit of an age in which so much has been done to annihilate time and space; and, doubtless, neither talent, energy, nor wealth would be wanting to make the attempt, could even a chance of success be shown.

At the close of the last century the great Napoleon attempted to conquer the "Land of Egypt," then, as now, the key to our Indian Empire; and he was convinced that the permanent possession of that land was the key to universal empire. The measures adopted by him to retain it in his grasp were worthy his genius. To him is due the conception of the canalization of the Isthmus of Suez, and he argued, if a direct means of communication with India could be effected, not even England, with all her wealth and manufacturing powers, could compete commercially with Marseilles, or any of the Italian, Greek, or Austrian ports of the Mediterranean, each of which would have the advantage of being nearly half the voyage in advance of this country, as the following table will show:—

Distances to Bombay.

	<i>Via Suez.</i> Miles.	<i>Via Cape.</i> Miles.
Constantinople	5,400	18,300
Trieste	7,020	17,880
Marseilles	7,122	16,950
Cadiz	6,672	15,600
London	9,300	17,850

No doubt the attempt to unite the two seas would have been made had Napoleon been left in quiet possession of the country, but the British, in those old-fashioned days, strongly objected to the occupation of a road to their possessions, and therefore summarily ejected the French from Egypt. The idea of joining the Mediterranean and Red Sea by means of a canal received, as already observed, its first impulse from the great Napoleon, and, since that period, various plans have been devised to carry out such an undertaking, all of them, however, based on the result of the levellings of the French Savans in 1799, who reported that the Mediterranean was 30 feet below the level of the Red Sea at Suez. It appears to have been a received opinion of the ancients that a difference of level must exist between any two neighbouring seas.

The Egyptians no doubt assumed a difference of level, which was

the more extraordinary as they were such excellent hydraulic engineers: even the French fell into the same error; in short, such a notion prevailed until very lately:—for instance, the Mediterranean was conceived to be higher than the Atlantic; the Euxine as much as 40 feet above the *Ægean*; and, still more strange, the gulfs of *Egina* and *Corinth* were supposed to have a very great difference of level. Even as late as the commencement of this century few dared call this theory in question, but it is worth noting that *Laplace* and *Fourier* came to the conclusion that a difference of level was impossible.

In the present day it is received as an axiom that no matter how narrow the separation between the two seas, both of them belong essentially to that vast expanse of ocean, and are therefore subject to the same levelling law.

This fact was not proved till 1846: in that year *M. Talabot*, an eminent engineer, *M. de Negrelli*, an Austrian, and *Mr. Robert Stephenson* entered into a formal agreement to share the labour and cost of a preliminary investigation, with a view to test the practicability of a project suggested to *M. Talabot* by *Linant Bey*, a French engineer, resident many years in *Egypt*,—namely, cutting a canal across the *Isthmus of Suez*.

A corps of scientific engineers was accordingly sent out, and reported in January, 1847, that, after the most careful series of levels, they had ascertained beyond question that no difference of level whatever existed between the two seas, and that consequently a canal, capable of being scoured by the waters of either sea, was impracticable, especially as both may be said to be nearly tideless.

The arrangements made by the three gentlemen just named were as follows:—*M. Talabot* was to superintend the levelling operations, *M. de Negrelli* to undertake the hydrographical inspection of the *Bay of Tineh* or *Pelusium*, while *Mr. Robert Stephenson* examined the *Red Sea* outlet of the proposed canal in the vicinity of *Suez*.

Circumstances prevented *Messrs. Talabot* and *Negrelli* from visiting *Egypt*, although they were represented by carefully selected employées, but *Mr. R. Stephenson* made a personal inspection of the ground, and thoroughly mastered all the scientific and technical details of the project. The result of these admirable arrangements was a complete exhaustive survey of the locality, which led to the unanimous conviction that the construction of a direct canal between *Suez* and *Tineh* was a difficulty insurmountable.

A comprehensive report of these proceedings was drawn up by *M. Talabot*, and is one of the most lucid documents ever written on the subject. The evidence just detailed appeared so conclusive that

all idea of joining the two seas by an open cut was abandoned. It may be interesting to state that the cost of the investigation amounted to no less a sum than 4500*l.*, which was paid by the gentlemen I have named, to whom doubtless the credit is due of setting at rest the much-vexed question of difference of level between the Mediterranean and Red Sea. Since 1847 the Isthmus has been twice re-levelled, each time with the same result as at first.

For several years the Suez Canal project remained closed and abandoned, but the idea of overcoming a barrier apparently so insignificant as the Isthmus was not permitted to rest. M. Talabot himself suggested a plan by which he hoped to lessen some of the difficulties. Messrs. Barrault likewise submitted proposals, and both these projects I shall briefly detail.

M. Talabot proposed to start from a point about 6 miles below Suez, where deep water is found near the shore; to follow the "Ouadee Toumilat," and proceed to within a short distance of Cairo, to cross the Nile above the Barrage without making use of the stream itself; thence to take the direction of Alexandria, where the canal would terminate in the old harbour. The length of the canal would be about 250 miles, breadth 328 feet, and depth 26 feet, and it would be fed from the Nile.

M. Talabot proposed to cross the Nile by an aqueduct, the surface of the water in which was to be raised 40 feet above the level of the high water of the Nile, and 60 feet above the low water level. It was to be 3500 feet in length, and reached by four locks at each end, by which the summit level could be attained by the largest ships.

This aqueduct would indeed be one of the wonders of the world. M. Talabot was quite alive to the difficulties of the scheme, but he offers the proposal as preferable to a direct canal from Suez to Pelusium.

The plan of Messrs. Barrault is to proceed from Suez to Lake Mensalah in a direct line, then to turn in a direction parallel to the sea for a distance of more than 100 miles, into the *new* harbour at Alexandria. Instead of crossing the Nile above the Barrage, it will be seen that they prefer carrying their canal across the mouths of the Damietta and Rosetta branches. Neither of these schemes offers a solution of the problem, for independently of the enormous expense and many engineering difficulties frankly admitted by the projectors, local and political causes present such serious impediments as to be of themselves decisive against either proposal.

In spite of the conclusions arrived at, after the most careful investigations of the eminent engineers mentioned above, that the direct

canal from Suez to Tineh was impracticable, the project has been again revived.

M. Lesseps, a gentleman who formerly held a diplomatic appointment in Egypt, has taken up the question with an energy and zeal worthy of success.

In November, 1854, he presented to Said Pasha, the present Viceroy of Egypt, a memorial on the subject, which sets forth:—

“That the utility of a navigable canal joining the Mediterranean and Red Sea has always been recognised.

“That Napoleon when leaving Egypt said, ‘It is an important affair; it is not now in my power to accomplish it, but the Turkish Government will perhaps one day owe its preservation and its glory to the execution of this project.’

“That the moment has now arrived to realise Napoleon’s prediction.

“That M. Lepère (50 years ago), Linant Bey, Gallici Bey, and Mangel Bey, agree in the possibility of a direct cutting.

“That the cost of the canal of Suez is not out of proportion with the utility and profits of this important work, which would curtail by more than one half the distance of India from the principal countries of Europe and America.

“That the pilgrimage to Mecca will henceforth be assured and facilitated to all Mussulmans; an immense impulse given to steam navigation and to distant voyages; the countries on the coasts of the Red Sea and the Gulf of Persia, the eastern coast of Africa, India, the kingdom of Siam, Cochin China, Japan, the vast Empire of China with its more than 300,000,000 of inhabitants, the Philippine Islands, Australia and that immense archipelago towards which the emigration from old Europe is directed, brought nearer by nearly 3000 leagues to the Mediterranean Sea and the north of Europe,—such are the sudden and immediate effects of cutting through the Isthmus of Suez.

“That the yearly European and American traffic round Cape Horn and the Cape of Good Hope is 6,000,000 tons, and the world’s commerce would realize 6,000,000*l.* annually by sending the ships *viâ* the Gulf of Arabia.

“That if only 3,000,000 tons passed through the canal, there would be an annual produce of 1,200,000*l.* by collecting 10 francs per ton.

“That the political advantages are equally incontestable. To England—mistress of Gibraltar, Malta, the Ionian Islands, Aden, important stations on the east coast of Africa, India, Singapore, and Australia; to France; to Germany,—for Prince Metternich and

Baron de Bruck have long seen that in the question lay the aggrandizement of Trieste and Venice ; to Russia, United States, Spain, Holland, all the towns of Italy, and ports and islands of Greece."

In consequence of the above representations the present Viceroy of Egypt, Said Pasha, granted a firman of concession to M. Lesseps, subject of course to the approval of the Sultan. M. Lesseps' first step was to cause MM. Linant Bey and Mangel Bey to examine the ground, and submit to him a plan of operations and an estimate of expenses. Their report, which formed the groundwork of future proceedings, may be briefly summed up as follows :—

The canal starts from the eastern portion of the Gulf of Suez : it traverses, taking a direction almost due north, about $15\frac{1}{2}$ miles, which separate Suez from the basin of the Bitter Lakes. It traverses also these lakes unembanked, and from the northern extremity of the Bitter Lakes it proceeds, cutting through the plateau of Serapeum towards Lake Timsah. This lake it also traverses, and, winding round the plateau of El Guisr, it skirts the eastern border of Lake Mensalah, and falls into the inner part of the Bay of Pelusium, whence it is prolonged into the sea until it reaches a depth of 24 feet. The width proposed was 330 feet, and the minimum depth 21 feet below low water of the Mediterranean. The locks, two in number, were to be 330 feet long, 70 feet broad, with a minimum depth of 21 feet. The estimated cost for the entire undertaking amounts to 162,550,000 francs, or about 6,500,000*l.* sterling, and it was calculated that six years would be required for the completion of the work. It has been proposed to modify this plan by removing the point of junction with the Mediterranean 18 miles to the westward, and to do away with the locks altogether ; the canal will therefore be 92 miles in length without a single lock. M. Lesseps now proceeded to make his scheme public, and followed up that act by appointing in the name of the Pasha an international commission, composed of 13 gentlemen well qualified to give an opinion on the subject. The different countries were represented as follows :—England, 4 ; France, 4 ; Holland, 1 ; Germany, 2 ; Spain, 1 ; Italy, 1. Their published report, which is an extremely able document, confirms that of MM. Linant Bey and Mangel Bey in every essential particular, but does not mention the mode of constructing the ship canal, or supplying it with water, and not a word is said of the difference of opinion which existed among the members. A difference of opinion, however, did exist, and one of no mean importance, inasmuch as one party pronounced in favour of M. Lesseps' scheme, while the other declared it impossible to dredge or cut a channel through Lake Mensalah at a depth of 24 feet

below the Mediterranean, and thence across the Isthmus of Suez to the Red Sea. M. Lesseps, however, was naturally anxious to insure unanimity at Alexandria, and himself suggested that every word relating to the mode of construction and supplying with water should be omitted in the report and reserved for discussion in Europe. At the discussion the majority of the commission voted in favour of the open cut without locks; the minority proposed another plan, which might be considered feasible, while they regarded the open cut as impracticable: their project is to construct a ship canal in nearly a direct line between Suez and Port Said, the level of top water throughout the whole length (93 miles) to be 23 feet above the low water of the Mediterranean Sea; the embankment to be carried into the deep water of the sea at each extremity, so as to avoid the necessity of dredging, and the locks to be constructed similar to the sea lock of the Caledonian Canal. The canal to be supplied with water from the Nile, at a point below the Barrage suitable for that purpose.

This, then, is the present condition of the scheme; opinions are divided as to its practicability, and M. Lesseps now only waits the formal permission of the Sultan and the Pasha of Egypt to commence operations. I shall now endeavour, as briefly as possible, divesting the question of all technicalities, to show cause why the cutting a canal across the Isthmus of Suez is a hopeless undertaking.

Commencing with the Mediterranean outlet of the proposed canal, viz. Port Said, we find that a harbour has to be built which is in itself a colossal work; the piers composing which would aggregate at the very least seven miles in total length, of an uniform depth, certainly not under thirty feet, with parapets and lighthouses of considerable height.

The material for the rubble-work alone can only be obtained at a distance of a hundred miles, while the stone for the finishing-work is much farther off, in the islands of the Mediterranean; thus, then, the building operations would assume gigantic proportions. To bring a case in point familiar to all, this part of the undertaking would demand twice the labour and material required for the construction of the Breakwater at Plymouth. But when, in addition to this, it is known that the site of the proposed harbour is on an exposed and shallow coast, subject to violent gales, a lee-shore a great part of the year, and with the bottom of the sea uncertain as a foundation for the piers; and, lastly, when it is borne in mind that the well-known prevailing mud-carrying current must soon silt up the entrance and channel, and that dredging can only be resorted to under favourable circumstances, the most unthinking must

see that the success of this undertaking is involved in the greatest uncertainty. Before leaving this part of the subject, I will briefly allude to the cost of such a work. Take the Breakwater at Plymouth for example, which cost 1,500,000*l.*, and was twenty-eight years in finishing: surely a work of twice its magnitude and labouring under much greater disadvantages would cost twice as much; but, instead of the estimate of Port Said being 3,000,000*l.*, it is only put down at 842,362*l.* in M. Lesseps' scheme. We now come to the canal itself, an open cut without locks, of 92 miles in length. To dredge such a cut 26 feet below low water of the Mediterranean has been pronounced impracticable by the very highest authority.

I shall not touch on the technical points of objection, but merely ask you to picture to yourselves the cutting a trench 92 miles in length, 330 feet broad, and 26 feet below the low-water level of the Mediterranean; for though it is true that certain depressions occur on the route, viz. Lakes Timsah and the Bitter Lakes, yet one is only two feet below the Mediterranean, and the other would require embankments; and when the cutting through the elevated ground is taken into calculation, it will be quite evident that the gain is balanced by the loss. The mere labour of such a work is enormous; but when the nature of the soil is considered, it indeed assumes a hopeless appearance; the sand to an average depth of 13 feet might be removed, but at that depth water is met with. Lake Mensalah has the character of being like a quicksand, and most probably the entire subsoil will prove more or less the same. Yet for this gigantic undertaking the estimate is only 3,500,000*l.* As a check to this estimate, I will remind you of the dimensions and cost of the Caledonian Canal, one of the largest ship canals in the world: its cuttings are about 25 miles, its depth 15 feet, width 50 feet, and cost about 1,000,000*l.* The Suez Canal in actual length only is nearly four times as long, but when the breadth and depth are considered it cannot be calculated at less than eight times the size. To be within the mark in making a comparison of cost, always supposing no greater difficulties than those met with in the construction of the Caledonian Canal, I consider 6,000,000*l.* the least sum that can be required.

We now arrive at the Red Sea outlet of the canal, viz. the Port of Suez, and here again difficulties are met with. Piers of scarcely less aggregate length are proposed, which traverse a sandshoal; lighthouses, &c., have to be constructed; but as the material is close at hand, these difficulties may be overcome; the estimate, however, of 345,982*l.* 9*s.* 7*d.* seems out of proportion to the nature

of the works, and, judging by the cost of similar undertakings, 1,500,000*l.* would at least be required.

Thus it appears that, supposing only ordinary difficulties occur, the sum of 10,500,000*l.* would be requisite for the mere construction of Port Said, 92 miles of canal, and Port Suez. M. Lesseps himself fixed the contingent work and other expenditure at 3,500,000*l.*, therefore the grand total for works would amount to 14,000,000*l.*; when, however, the serious obstacles I have detailed, and which will inevitably be met with, are taken into consideration, it must be evident that the 14,000,000*l.* I have named may be increased *ad infinitum*; in fact, from the outset the utmost uncertainty regarding expenses must prevail. At first sight it seems difficult to understand how such a small estimate as 8,000,000*l.* could have been supposed sufficient. But it is probable that Messrs. Linant Bey and Maugel Bey have been dealing with forced labour, and the expenditure of money of which no account has been given. This forced labour is slavery in its worst form. The Fellahs are compelled to leave their homes at the will of the Pasha: the Mamaudieh is a melancholy instance of this; 20,000 of the workmen are said to have perished during its construction. Males of all ages, from children ten years old and upwards to old age, are taken from their native villages and made to work. I have myself often seen the poor wretches in gangs of hundreds, surrounded by overseers with sticks, whose duty it was to beat any symptoms of laziness out of them. The Fellahs naturally look upon the canal scheme as the certain grave of thousands; they know the locality is entirely destitute of water, and they have vividly in remembrance the late disasters in the vicinity of Suez, when so many of their numbers perished. The Fellahs, it is true, make excellent navvies—witness the railway they have constructed; but in that instance they entered into the spirit of the work and appreciated its importance, in proof of which they lately volunteered to make the embankment, if the rails were provided, from the main line to Samanhour, and also to Zagazig, both of which branch lines are now in course of construction, and when finished will open up the richest part of the Delta.

Having now disposed of the question of practicability, let us examine whether, under different circumstances, the Suez Canal would have been a paying concern. The facts I am about to quote are of the latest date, and have been in the kindest manner furnished by the Peninsular and Oriental Company and the Board of Trade. In the first place, the distance from England to the East Indies (say Calcutta, for instance) is 13,000 miles *viâ* the Cape of Good

Hope; while, by way of Gibraltar, through the proposed canal, and down the Red Sea, the distance is 8000, showing a difference of 5000 miles in favour of the canal route. This is apparently a great gain; but, upon reference to the difficult navigation of both the Mediterranean and Red Sea, it will be found that the average passage of twenty fine ships last year to Alexandria was 54 miles per day, and of twelve ships to Suez 25 miles per day. Now a small average, by way of the Cape of Good Hope, is 130 miles per day; therefore, basing the length of voyage on that calculation, the distance from England to Calcutta by way of Suez would be 16,000 miles, without taking into consideration the length of the canal or the delay in passing through it. This is conclusive as showing that the voyage round the Cape of Good Hope can be made in a shorter time than by the proposed canal, to say nothing of the dangers of the Red Sea, which occasion the loss of one ship in ten traversing its waters. We will now glance at the financial prospects. The arrivals in the United Kingdom of English and foreign vessels from ports of the East Indies, by way of the Cape of Good Hope, amounted last year to 718,992 tons. Supposing all these ships used the canal, the revenue, at 10 francs per ton, would not amount to 300,000*l.* per annum, not quite 4 per cent. on the low estimate of 8,000,000*l.*; but, as shown above, the canal route would never be chosen by sailing ships; and, as the transport of goods of little value compared with their bulk must, from the small stowage in steamers, be forwarded in sailing vessels, therefore a very large number will ever continue to make the voyage round the Cape of Good Hope, even if the canal were completed. As the proportion of sailing-vessels to steamers in England is 13 to 1, the largest steam mercantile marine in the world, it will be seen at a glance how few vessels there will be calculated to benefit by the proposed canal.

Reviewing all the circumstances I have detailed, it seems clear that the direct open cut from Pelusium to Suez is impracticable; that any canal would be useless except for steamers; that the proportion of that class of vessel is so small that the tolls collected upon the whole number would not maintain the proposed gigantic works; and, finally, that the opening of a direct cut across the Isthmus of Suez would be merely adding 100 miles to the delays and difficulties of Mediterranean and Red Sea navigation.

While I have not hesitated to denounce the union of the two seas by a direct cut across the Isthmus of Suez as hopeless and impracticable, I have not lost sight of the necessity of diminishing by every possible means the time occupied in the voyage between the mother country and her colonies. The importance of maintaining a rapid

means of communication with India has been abundantly demonstrated by the late stirring events in that country, and, although it is true that the "Overland Route" is indeed a stride in the right direction, and calculated I believe to maintain a supremacy over any other route, yet it is still in its infancy. At Alexandria itself, for instance, difficulties and delays are met with in consequence of the harbour being open to the prevailing winds, which often blow with great violence.

The management of the railway from Alexandria to Cairo is most faulty, while the continuation of the line to Suez is positively dangerous, and the roadstead at that terminus inconvenient and tedious for the transshipment of goods and passengers; but, before entering more fully on that subject, I will briefly detail the rise and progress of the present mode of transit from Europe to the East Indies.

Very early in the present century attention was directed towards an overland route to India, but it was not until 1823 that any movement of consequence was made. Certain members of the Indian Government proposed to the home authorities to forward mails and passengers by way of the Red Sea, across the Isthmus of Suez, and thence through France or by sea to England; but this proposition did not meet with favour.

After allowing the above proposal to germinate for three years it was again brought forward, but still did not produce fruit. The Government advanced a host of objections against the plan, and it is doubtful how long this state of affairs might have lasted had not an individual cut the Gordian knot. In 1827 Lieutenant Waghorn, R.N., turned his attention to the establishment of a "steam communication between our Eastern possessions and their mother-country, England," and to his exertions is mainly due the present overland route. Years elapsed before its practicability was acknowledged: Lieutenant Waghorn was obliged to test his plan by repeated journeys to and fro, at his own risk and expense, and in the teeth of a determined opposition. A parliamentary committee condemned the project, and the Chairman of the India Company declared "that they required no steam to the East at all." Nevertheless, Lieutenant Waghorn at last succeeded in making the feasibility of his route to India apparent to the meanest capacities. The following despatch, sent by the Indian Government in September, 1836, will show the estimation in which a comparatively rapid means of communication with the mother-country was held in India:—

"We beg to offer to your Honourable Court our congratulations

on the rapidity with which your wishes have of late been conveyed to all parts of your Indian possessions. The three last overland mails have brought despatches from London to Bombay in 58, 45, and 64 days, and those intended for Calcutta have been forwarded in 10 days. We have witnessed the energetic impulse this early intelligence has given to the mercantile interest, and the unbounded satisfaction it has diffused throughout all classes of the community. It is, indeed, undeniable that a quick interchange of information is of the first advantage in commerce, and in the conduct of all public business; while it is equally true that its effect on the minds of those who serve the Honourable Company long and faithfully in this distant land, is to deprive the painful feeling of separation from their homes and country of half its bitterness. We beg respectfully to press these reflections on the notice of your Honourable Court, with our earnest prayer that you will, ere long, grant to India the much desired boon of frequent and regular communication with Europe by the employment of a sufficient number of steam-vessels for that purpose."—*Porter's Progress of the Nation*, p. 320.

The "Overland Route" being an established fact, attention was soon directed towards its improvement, which has since been surely, though slowly, progressing. At first, the mails from India to Suez were brought by the ships of the East India Company, but in 1841 a contract was made with the Peninsular and Oriental Company, and since that period no expense or exertion has been spared by them to exceed even the terms of their contract. The next improvement which superseded the tedious and painful journey by Nile-boat, van, and camel, was the completion of a railway, first from Alexandria to Cairo, and then from Cairo to Suez.

This great work has considerably shortened the journey, and, what is more, has found favour even in the eyes of the ignorant Mohammedan inhabitants. It will be interesting to detail briefly the history of these two railways, for, though they form one great line, yet the one is as different from the other as it is possible to conceive.

The construction of the line from Alexandria to Cairo was undertaken by Mr. Robert Stephenson; it was commenced on the 9th of February, 1852; reached the Nile at Kafr Azzayat, exactly half-way between Alexandria and Cairo, on the 4th of July, 1854; and finally entered Cairo on the 1st of December, 1855, having been three years ten months in completing.

There are eight stations; the line is perfectly level the whole way, with only one cutting through the mound of a deserted village, and its entire length is 131 miles. Iron sleepers are used, supported

on bells of the same metal, a plan adopted by Mr. Stephenson, as admirably adapted to sustain the rails on the peculiar soil of Egypt.

The difficulty in crossing the Nile was obviated by means of a steam ferry, the striking peculiarity of which arises from the necessity to adapt the floor and rails to the exact level of the railway at each side, under the extreme variation of level to which the waters of the Nile are subject. By an ingenious mechanical contrivance, the platform is raised or depressed as the waters of the Nile require, and this, together with an exact adjustment of the rails and the most perfect facility of access to and egress from the framework, is ingeniously provided for. The entire cost of this ferry amounted to 15,000*l*.

A handsome iron bridge, which will supersede the ferry, is in course of construction, under the direction of Mr. Rouse, C.E., and will be opened for traffic in June next.

The entire cost of the railway-works from Alexandria to Cairo is under 1,000,000*l*., or less than 7500*l*. per mile. At present, the time occupied in the journey from Alexandria to Cairo is seven hours, but when the bridge at Kafr Azzayat is opened to traffic a great reduction will take place.

The completion of this half of the transit line was hailed with great rejoicing; every difficulty had been triumphantly grappled with: the native Fellahs, owing to excellent arrangements made for their comfort and welfare, had escaped the disasters usually attendant upon the construction of public works in Egypt, and, what is more, so thoroughly understood the utility of the work they were employed upon that, as already mentioned, they actually volunteered to make the embankments for two branch lines, one of which was completed in a year, and will open up the richest part of the Delta. It is the Pasha's intention to employ no one but Arabs upon these branch lines.

It now remained to perfect the transit route by a railway to Suez, and the obvious course the line should take was indicated, viz., to branch off from Benha, by way of Zagazig, through the Ouadee Toumilat (Land of Goshen) and past the Bitter Lakes to Suez. This route possessed two great advantages—a level country the whole way, and the means of obtaining abundance of water. It was, however, urged upon the Pasha that the English had enjoyed the emoluments resulting from the construction of the first half of the railway, and, therefore, to the French the remaining half ought to be devoted; accordingly, the continuation of the line to Suez was intrusted to a French engineer, M. Mouchelet. This gentleman

evidently did not consider the route I have just alluded to as the best, for he has carried his line from Cairo due east over the Desert, straight to Suez. Although several cuttings had to be made, no great difficulty was experienced except from the total absence of water, until reaching Gebel Awebel; but after passing that elevated ridge the obstacles met with in the descent to Suez became most serious, the curves which have been made are astonishing, requiring extreme caution to travel over safely, and instead of 90 or 100 miles, the line has in consequence attained a length of 130 miles. Much danger is incurred and unnecessary loss of time occasioned, there is daily expectation of a fearful accident, and last, though not least, owing to the lack of water, the train mileage for water traffic will always be five-elevenths of the train mileage for all other traffic, which will add immensely to the expense of working the line.

Dreadful disasters have taken place in consequence of the want of water, hundreds of Fellahs unable to obtain it have been seized with a panic, and missing their way to the Ouadee Toumilat in search of it, have perished miserably in the Desert. The line from Cairo to Suez was completed on the 7th of December, 1858. It is difficult to make an estimate of the cost, but it cannot be put down at less than 10,000*l.* per mile.

The time occupied on the journey from Cairo to Suez is from 6 to 8 or 9 hours, but the great expenses of working and the risk render it probable that the line will only be used as a temporary means of conveyance. We will now consider the means by which so desirable an end as shortening the road to India may be accomplished.

A passenger leaving Southampton by the "Overland Route," on the 4th of the month, arrives at Alexandria on the 17th. He leaves Suez on the 19th, and arrives at Aden on the 25th; thus, including the 2 days crossing the Isthmus, he is 21 days on the road from Southampton to Aden. Now it is most desirable that the passage of the Red Sea should be shortened, and I propose to do it by continuing the railway along the banks of the Nile as far as Assouan, and thence across the country to Berenice; the total line from Alexandria to Berenice would be 690 miles. At present the journey by railway is 260 miles, and the question is simply whether the remaining 430 can be better performed by steamboat or by rail.

Every one who has travelled on the Red Sea knows full well the suffering occasioned by the intense heat. The inconvenience of the Port of Suez is also well known, the steamers being obliged to lie at least 3 miles off the landing-place. Suez itself is simply a large

inn in the midst of the Desert, of use only as an entrepôt for goods.

The delays and difficulties met with on the present line from Cairo to Suez have already been alluded to.

Regarding the present proposition of a railroad from Alexandria to Berenice, if the speed of only 20 miles per hour was maintained, the journey could be performed in 35 hours; add to which 12 hours' rest at Thebes, and it will be seen that the entire passage will only occupy the same time now taken up between Alexandria and Suez: that is to say, the steamer will arrive as usual on the 17th, and the mails and passengers will be at Berenice, which is one third of the way down the Red Sea, instead of at Suez by the 19th, thus saving two clear days in our communications with India.

At Berenice there is a good and safe harbour, with sufficient water to allow the largest steamers to come alongside, and quays made for that purpose; therefore passengers, mails, and cargo could be transferred without the least difficulty or delay from railway to steamer.

The advantages are therefore a gain of two days in time, one third of the Red Sea passage avoided, and a convenient harbour at the end of the line, instead of the miserable Port of Suez.

The time of transit might still further be reduced by the construction of a pier at Alexandria, alongside which the steamers might go in all weathers, and thus avoid the usual delays.

The above advantages apply only to the improvement of the present Overland Route, but Egypt and the entire commercial world would share largely in the benefits of such improvements. For instance, the entire Nile Valley belonging to Egypt would be opened up, and a high road formed conducting to the heart of Africa, the inexhaustible riches of which country remain yet untouched.

Finally, the port of Berenice would be admirably situated for developing the Red Sea trade, which is at present slumbering for want of such an entrepôt.*

The maintenance of our Indian empire in its integrity is of vast importance, and nothing can so surely consolidate the rule of the mother country as a speedy means of communication with her possessions.

Shortening the route to India by two days is, doubtless, a great gain; and, as the time is past when the authorities can assert that "they require no steam to the East at all," it is to be hoped that

* Sir Gardner Wilkinson differs entirely from these views, and says that the "Port of Berenice has long since been filled up with sand, and has only a small quantity of water in it, even at high tide."—Ed.

the attention of those most interested in the matter will be given to the attainment of so desirable an object.

THE PRESIDENT.—We have known Captain Pim on various occasions. We recollect him as the gallant Arctic officer who offered to go in search of Franklin across Siberia, and we have known him, indeed, in various expeditions in search of our lost friend and his companions. Again, he is the individual who walked across that great mass of ice to Banks Land, to rescue M'Clure and his companions; for, had not Captain Pim performed that journey, Sir Robert M'Clure might never have revisited this country. We farther know that Captain Pim distinguished himself in the Baltic and in the late war in China, in which he was severely wounded and honourably won his promotion, and now he appears before us as a geographical statist. The paper has a very modest title, but it embraces a variety of important topics. He has analysed the different lines of route across Egypt, whether by railroad or canal, and has laid before us a plan of his own. I do not pretend to compare the merits of these various plans, but I am bound to say that Captain Pim has ably developed the observations and deductions of our very distinguished associate Mr. Robert Stephenson, whose surveys in Egypt are well known to geographers and the public, and who in his last visit was accompanied by the author of this memoir.

GENERAL W. MONTEITH, F.R.G.S.—It is great presumption in me to offer an opinion regarding a great work after the statement made by the able engineer who has lately been engaged expressly in the examination of the proposed Suez Canal. It has always been a subject which I had taken great interest in, and I was convinced of its practicability till I heard from Mr. Stephenson that no difference existed between the levels of the Red Sea and Mediterranean, which I had understood would afford a sufficient current to keep the Canal open. That not being the case, I at once ceased to consider the work practicable, so as to allow large vessels to pass through either loaded or empty. Excavating a canal of any dimensions might be accomplished, but it would lead to no result when it came out on a shallow coast, which would render the Canal inaccessible. It appears from history that at two different periods a communication did exist, and on both occasions the Canal did not go direct to the sea, but joined the Nile; but neither was intended or required for large vessels. This I think offers no considerable difficulty even at present. I have three times been at Suez, and on one occasion I visited a wall or embankment about three miles from Suez (to the east), which was said to have been built by a sultan of Egypt, to shut up the mouth of the canal, to prevent an Arab invasion. Whether this is correct or not I do not pretend to say. The question of a great ship canal is I think set at rest from the deposits left by the Nile to the east of Alexandria. But a small canal, joining one of the branches of that river, though it would not answer as a great point of transit for the world in general, would be a vast advantage to Egypt and the small vessels navigating the Mediterranean, but be certainly no advantage to the trade of England. Any plan which does not include bringing water to Suez will be imperfect, whether by canal or railway, as proposed by Mr. Stephenson. I again apologise for offering an opinion in presence of several so much better able to judge.

MR. GEORGE RENNIE, F.R.G.S.—As one of those who dissent somewhat from the opinions of Captain Pim regarding the canal, perhaps I may be allowed to look at the subject in an engineering point of view. I have read the statements of M. Lesseps, and I find nothing in them to justify the assertion that the canal is impracticable. In the first place, that canal is on the most direct line between Suez and the Mediterranean, and, with one or two small exceptions, it is nearly upon the level. Next, with regard to the alleged unfavour-

able character of the soil, what says M. Lesseps, and what say the borings taken by the Commission? They show a light coat of sand, and below that clay—the very article wanted for the canal. Then, as to the probability of the canal filling up by the flowing of the sand, M. Lesseps and the Commission found the remains of a Roman camp, and a camp of considerable antiquity, also the vestiges of the ancient canal of the Pharaohs, none of which works have been covered by the shifting sands of the desert. As to the expense of the harbours of Pelusium and Suez, the Plymouth Breakwater had been quoted as the datum for the probable cost of the piers at those harbours; but the case did not hold, as the Breakwater at Plymouth was an isolated Breakwater built in the sea, in which every stone had to be taken out in barges and deposited. The cost of that work was about 190*l.* per foot run. But the Portland Breakwater, of a similar area of section, consisting of jetties of stone projected from the shore, cost only 150*l.* per foot lineal. The Marseilles Breakwater, also of a similar area of section, built partly of stone and partly of béton or concrete, cost only 80*l.* per foot lineal; and, as this was the system proposed for the piers of the harbours of Pelusium and Suez, the cost would be less than one half of the Plymouth Breakwater, the circumstances being different in both cases.

The cost of the piers at Pelusium, one 3800 mètres in length, the other 2700 mètres in length, would, if carried out as proposed, not exceed 2,000,000*l.*, while the piers at Suez, of 2700 mètres and 2500 mètres in length respectively, would be proportionately less, or say 4,000,000*l.* for the harbours and 4,000,000*l.* for the canal, making 8,000,000*l.*, as estimated. But, supposing the cost of the whole project to exceed that sum, the object to be accomplished is worth it.

The greatest objection that I have heard is the report of Captain Spratt as to the formation of the Delta of the Nile. He states that the winds prevail from the north-west, and set in such a current upon the Pelusium shore, together with the muddy bottom, as to make it untenable for vessels to anchor in those roads. He also states that the piers would run out into the mud brought to the eastward by the current from the Nile, and thus render the works next to impracticable.* There are always two statements of a case, and I hold in my hand a pamphlet entitled 'Observations on the Bay of Pelusium,' by Captain Philigret,† who commanded a corvette in the service of the Viceroy of Egypt, and anchored it in that very bay for the purpose of testing in every respect the objections of Captain Spratt; and the results are totally at variance with what has been stated against the bay of Pelusium,—that, on the contrary, the anchorage is good, and that the bottom is sandy, and continues so to a depth of 10 mètres or 32 feet. With regard to the question of distance, M. Lesseps shows that it is not more than half the distance that it is by the Cape route; and he states that he is quite satisfied that a toll of ten francs per ton upon ships passing through is quite enough to pay the interest of the capital. Part of Captain Pim's argument was founded upon the dangerous navigation of the Red Sea. But the time is coming when sailing-ships will be superseded by steam-ships, and the interests of the commercial world will tell you how advantageous it is to take a steam-ship directly through the canal, and convey its unbroken bulk all the way to Bombay or Calcutta, instead of having to take the cargo out of the ship at Alexandria, land it, carry it across to Suez on the railway, and ship it again on the Red Sea. I do not pretend to know anything of the commercial part of the

* The International Commission propose that the Pelusium entrance should be placed 120 miles nearer to the Nile, and thus to shorten the piers.

† Observations Hydrographiques dans la Baie de Péluse, par M. le Capitaine Philigret, Commander of his Highness the Viceroy's steam frigate *Fez* Djahd.

question. I take these statements of M. Lesseps, and I find his scheme has met with unanimous approval at Liverpool, Leeds, Manchester, Glasgow, Dublin, and all the great commercial towns of England. Again, I cannot understand why this project should be pronounced impracticable after it has undergone the investigations of a Commission consisting of the first authorities in Europe. It is not likely these men would compromise their characters by asserting the possibility of a scheme which is now declared by the author of this paper to be impossible. I therefore think that simply as an engineering question the statements of Captain Pim, as to the impracticability of that canal, are at variance with the facts stated by M. Lesseps and verified by the Commission.

MR. S. SIDNEY said,—The question was one which could not be settled without the consent of England. British exports and imports in the port of Alexandria averaged nearly 4,000,000*l.*, or more than those of all the other nations trading there put together. British passengers paid for transit across the Isthmus upwards of 200,000*l.* per annum. British merchandise and specie were sent across here to the value of upwards of 28,000,000*l.* England is the only country that received duty free the whole produce of Egypt—grain, pulse, and cotton. Egypt was the road to India. The “gate of our house” old Mehemed Ali called it, and the Isthmus “the key of our gate.”

It did not require arguments to prove that if it were possible to cut a real Bosphorus across the Isthmus, through which our great ships could sail or steam without interruption, it would be an enormous advantage to our commerce, putting out of sight the political and military consideration that it would be an additional strait for us to watch and defend.

But, if a deep and open Bosphorus would be a commercial advantage, a shallow ditch, open only to flat-bottomed boats, useless for trade, but available for the *coup de main* of an invading army, was a thing to be resisted with all our strength. The piercing of the Isthmus of Suez was essentially a geographical question, and therefore eminently fitted to be discussed by the Society. It was not new; it had been discussed for sixty years, and, according to all the reliable evidence, it was impracticable. He also (Mr. Sidney) was prepared, but would not add to the picture drawn by his friend Captain Pim, of the Mediterranean, driven by north-eastern winds for nine months of the year on the long, low, flat, shallow, surf-beaten shores of the Delta; for ages on ages barren, treeless, devoid of every kind of material needed for construction by an engineer. But, in reference to the scheme of running out on the soft sand of the Pelusium shore two stone breakwaters of a united length of between six and seven miles, every stone to be brought either by sea from Valencia in Spain, or from Rhodes in Egypt, or 90 miles inland, with neither railroad nor common road for conveyance, he would remind the Society that at Plymouth, with stone close at hand, a breakwater $1\frac{1}{2}$ mile had taken twenty-eight years to construct, and cost 1,500,000*l.* sterling; Cherbourg, $2\frac{1}{2}$ miles, had cost 3,000,000*l.*; Portland, years in progress, was still proceeding bit by bit. And these works were executed with all the advantages of labour, fuel, food, and all the appliances of machinery to be had close at hand for money. At Pelusium every labourer, every ounce of food, every stick, every stone would have to be imported, and money loved not either labour or time. But, leaving the difficulties of founding a port on a delta to be dealt with by engineers, leaving them to treat of the Sisyphean task of dredging a deep channel in a soft flat, in the face of a never-ceasing current, he would step on shore and tell them what was the experience of the celebrated Frank-Egyptian engineers in cutting canals through such swamps as Lake Merozalah—the swamp through which was proposed to dredge twenty-five feet below the level of the Mediterranean. They say, in their Avant Propos, reporting to the Viceroy:—“It appears to them impossible to maintain in

proper repair a canal, the bottom of which was below the line of low water in the Nile, otherwise than by an enormous expenditure; and even if incurring this cost, it was uncertain whether the desired result would be obtained. In all cases where an attempt has been made to dig a canal below the low-water level, and more especially on the outskirts of the desert, in the Ghattat-Bey, for instance, it invariably happens that at about the level of low water a bed of loose sand is met with, as was the case at Masteroud on the Zafranieh. This constitutes an enormous difficulty and a source of expense, of which it is hardly possible to form any previous estimate. When even it is not sought to obtain any great depth below the level, 0·50 mètre (1' 7½") for instance, annual dredgings of a really formidable nature are required. Thus in the Ghattat-Bey, the labour of 30,000 or 40,000 men is required for the space of a month to clear out the feeder at the point of junction; in the Chibin, from 20,000 to 30,000 men are employed; and from 15,000 to 20,000 for the Chercaouieh. In the case of the Moëze, all attempt to dredge it has been given up. To justify the withdrawal of so considerable a number of hands from the ordinary employments of agriculture, nothing short of absolute necessity can be admitted—a great damage to the resources of the country is thus occasioned, and so serious a result should, if possible, be avoided."

But it was not given to every one interested in this question to visit Egypt, to travel on foot or by camel over the disputed land, and see the sands, the swamps, and the flat Pelusian shores with their own eyes. The general public must form their opinion on evidence, and not by the number but the quality and the qualifications of the witnesses. The feasibility of the route originally rested on the theory of the Red Sea being thirty feet above the Mediterranean, and thus affording a headwater sluicing power to wash out a channel and keep a clear way through the artificial harbour proposed to be built at Pelusium. While that theory prevailed in 1835, General Chesney in 1843, Captain Vetch, and Mr. Anderson, of the Post-office, a successful merchant, but no engineer, all three supported the proposal for cutting through the Isthmus. But, as Captain Pim had related in 1847, M. Talabot, Mr. Robert Stephenson, and Mr. Negrelli, an Austrian engineer, having contemplated embarking in an undertaking for cutting a canal between the two seas, began by examining and levelling the route. Then, before this exact examination, the myth of the Red Sea headwaters disappeared, and the scheme of the canal naturally disappeared with it. M. Negrelli appeared convinced, for he was silent for nine years; M. Talabot printed a report, in which he exhausted every branch of the subject in an historical, geographical, and engineering point of view, and decided that the idea of a salt-water canal, since proposed by M. de Lesseps, was an absolute absurdity. And it was his (Mr. Sidney's) firm opinion that, if M. Talabot's work had been circulated in a popular form in the three leading European languages, the project of the Isthmus of Suez Bosphorus would long since have been consigned to the limbo of unfortunate projects. In 1851 Mr. Stephenson, before the Institute of Civil Engineers, publicly pronounced the canal scheme impracticable.

In 1856 the Suez Bosphorus scheme was again examined by two of the International Commissioners, Mr. M'Clean, who was living, and his (Mr. Sidney's) late lamented friend Mr. Rendel, one of the Presidents of the Institute of Civil Engineers, Consulting Engineer to the Admiralty, and Engineer of several Breakwaters and Harbours of Refuge. Mr. M'Clean visited Egypt, and, conjointly with Mr. Rendel, prepared a detailed report on the Lesseps plan, and concluded in the following words as to the harbour of Said:—"No dredging can take place until a temporary harbour has been constructed, as it is a lee shore for nine months of the year. There will be no breakwater to keep the channel open; on the contrary, there will be a gradual flow into the canal, which will tend to form a new beach in the harbour and

canal. There will be no certainty that the work will ever be finished. It will altogether depend on contingencies, over which the engineer has no control, and which cannot be estimated. Therefore the construction (under M. Lesseps' system) *may be regarded as impracticable.*"

Thus, then, in 1847, a French, an English, and an Italian-Austrian engineer abandoned the scheme as impossible when they discovered the mistake on which Napoleon's scheme was founded; and thus in 1856 M'Clean and Rendel, after mature examination, fortified by the local evidence of the Egyptian engineers, agreed with Talabot and Stephenson. But Mr. Stephenson was present, and would doubtless give the result of his repeated personal examinations. He would speak with all the force of high scientific acquirements and more than thirty years' labour on public works on lands, on rivers, and on seas, the greatest, the most novel, extraordinary, and successful that had ever been attempted in ancient or modern times.

MR. DANIEL A. LANGE, F.R.G.S.—The discussion this evening on the subject of the Suez Canal cannot fail to be of the highest importance, as expressing in how far the feelings and opinions of Captain Pim and some Fellows of this enlightened Society are in accord with the Academy of Science in Paris, and other eminent engineers, on the subject of the Suez Canal. Appreciating as I do the full weight and learning which is brought to bear upon all questions submitted to its discussion, and aware also of the interest, I may almost say excitement, which is felt in Europe on all matters connected with it, I hope the few observations I have to make may not be considered unworthy of your consideration. There is one point I would rather not have touched upon—it is the engineering question. I am aware that there has been much warm feeling and controversy about the different opinions held by the engineers; but it is one which, having been gone into this evening, I cannot well pass over, and as Mr. Stephenson is here, he will correct me if I fall into any unintentional misstatements. I have no wish to entangle myself in any scientific controversy between the eminent engineers who now take part in this discussion, and will leave to those competent to deal with such matters the task of enlightening the public on this important question; but, for the benefit of the uninitiated and those who may not have had time or inclination to wade through the different opinions held by opposite parties, I have deemed it not ill-timed to place the point at issue as simply and clearly as I can before you. Mr. Robert Stephenson holds the opinion—and, whether rightly or wrongly, it is not for me to decide—that after it had been ascertained beyond a doubt that no difference of level existed between the Mediterranean and the Red Seas, the project for cutting a canal through the Isthmus of Suez became impracticable. On the other hand, engineers of equal eminence state just the reverse, and view the non-existence of any difference in the level between the two seas as the very circumstance which will render its construction perfectly feasible. Now the question arises, who is right? And you will have to deal with the evidence before you. You must either pin your faith to one or other party, and make your choice between the opinion held by Mr. Robert Stephenson and that held by other engineers. Either Mr. Stephenson is right and they are wrong, or their collective opinions are of greater value than that of Mr. Stephenson. You will have to judge for yourselves, and my object in bringing this matter before you is, with an earnest desire for truth, to endeavour to state, as impartially as possible, the full value of the evidence with which you have to deal. The lateness of the evening prevents me from entering fully into the objections raised, and which have been so ably met by Mr. Rennie; but I wish to hand in the following condensed statement of the opinions already alluded to,* and I think I cannot do better than refer to

* See p. 203.

the "Report" itself of the "International Scientific Commission," copies of which, together with an atlas showing the configurations of the Isthmus, have been presented to the Society. From these elaborate works it will be seen that every possible contingency likely to occur, and every objection likely to be raised, has been fully anticipated and met. I may farther mention that, since the period of its publication, increased labour and study has been devoted to this important undertaking; that specimens of the borings along the whole track through which the canal will have to be made can be seen at the Geological Museum at Paris. I beg it will be distinctly understood by the present meeting that, although I represent the Company in this country, I have not taken part in this discussion with the object of making proselytes with a view of engaging their financial co-operation. The time for this has passed, and the list for subscriptions was closed on the 30th of November last year. The capital subscribed, and the amount of calls required, have been paid up. I think this statement due to myself in order to dispel any notions, which I do not believe exist here, that I have entered into this discussion with any other motives than to endeavour, however inefficiently, to refute on purely scientific grounds the arguments which have been put forward against the execution of the canal. In conclusion, I can only say that I believe all arguments respecting the feasibility of the undertaking have been placed beyond the pale of controversy; nevertheless I shall be happy at all times to afford any information which it is in my power to give to this Society. I consider that we have now arrived at the time for practical operations. Mr. Ferdinand de Lesseps, accompanied by the contractor of the works and a staff of engineers, is at present in Egypt, employed in staking out the ground through which the canal will have to be cut. Ship-loads of timber and other materials have already left the port of Marseilles for Egypt, and all the preliminary steps are being taken for commencing the works; and I earnestly trust that, before six years have elapsed, this great problem, which has occupied the minds of men for centuries, may be finally and successfully solved for the benefit of all nations.

MR. ROBERT STEPHENSON, M.P., F.R.G.S.—I entered this room with a firm determination to avoid all controversial points, and with a sincere intention of conveying to you the impressions I received as to the physical geography of the country, after having twice walked over it, which I conceive render the completion and maintenance of this undertaking absolutely beyond the power of man. Now, the most remarkable statement I ever heard of was the one urged just now, that there being no difference of level between the two seas really rendered the thing more practicable than ever. Negrelli, Talabot, and I were induced to begin the investigation, from its being stated as a positive fact that there was a difference of 30 feet in the level—a circumstance which would have offered the only chance of the scheme being practicable. Now, we hear to-night that there is no difference of level at all, and that this makes it more practicable than ever. Can you conceive anything more absurd? I cannot. I was astonished at the assertion of my friend Mr. George Rennie as to the breakwater at Pelusium, and comparing it with the Portland breakwater. Why, at Portland the stones are carried out from the shore and thrown into the sea; but at Pelusium there is no shore, and all the stones must be brought a hundred miles. Is there any comparison between a breakwater at Portland and a breakwater in the Mediterranean on a lee-shore, where there is no stone and no foundation whatever? It is nothing but the silt of the Nile. The Nile brings down millions of tons of mud, and in course of time had thus formed the delta at its mouth. This delta has protruded itself a long way into the sea, owing to the contrary action of the current of the Nile and its branches on one side, and of the current of the Mediterranean along the shores of Africa on the other. The moment, then, that you construct a harbour at

Port Said, and project piers out into the sea, you immediately arrest the course of the mud, and you will never be able to keep the port open. It is the most extraordinary thing in the world to project two jetties into an open sea on a lee-shore, which has for almost three-parts of the year a north-west wind blowing upon it. A steamer even, in a rough sea, dare not enter between two piers 300 feet apart; there is no seaman, except in fine weather, who would venture to approach such a place. To render it at all accessible and safe, there must be a harbour of refuge made, and we know from experience in our own country what a large question this would open up. Really, the physical difficulties are as I believe insurmountable. Supposing the harbour were made, it must be a mere mud trap. The current carried the mud of the Nile in an easterly direction, and if you erect a harbour of refuge, which means a quiescent harbour, it will become a mud trap. That is the peculiarity of all deltas. I believe it to be nearly true, if not absolutely true, that there is no large harbour in the world maintained on the delta of a large river. I know the delta of the Rhone, the delta of the Po, and the delta of the Danube, and I know the delta of the Nile. They are all alike incapable of maintaining a harbour of refuge, or even a good harbour of entrance; the harbour would absolutely be filled up in a few years. And with respect to the canal itself, now that it is proved there is no difference of level, it would really remain a stagnant ditch, and must ever remain so. Whoever has travelled over that district, and seen the moving sands, must see that it would be necessary to dredge, not only the harbour, but the canal itself.

MR. LANGE'S *Statement.* See p. 201.

"The very existence of Holland depends upon the engineering skill displayed in works of this description, and M. Conrad, after devoting a whole lifetime to them, holds under the Dutch Government the office of chief engineer of the Water Staat. Surely the opinion of such a man must be of value, and we are naturally curious to ascertain what views this gentleman entertains as to the feasibility of making the canal. It appears that M. Conrad, after bestowing more than two months of his valuable time to a very elaborate personal survey of the entire tract, returned from Egypt with views diametrically opposite to those expressed by Mr. Stephenson, and considers the non-existence of any difference of level between the two seas as a circumstance which will greatly facilitate its construction, and render it easy of execution. But if there could exist any wavering or hesitation in the mind of the public, I apprehend that the opinion of another engineer, not less eminent than M. Conrad, would in a great measure tend to remove it. I am alluding to M. de Negrelli, who holds the highest functions in Austria as an engineer. M. de Negrelli shares unconditionally the views held by M. Conrad. But the evidence does not end here; we have on record the opinion of Signor Paleocapa, Minister of Public Works in the kingdom of Sardinia, whose experience in the construction of jetties and canals leaves no doubt as to the value of his testimony.

"But lest all this should not be considered sufficient, the opinion of M. Lentze, Chief Engineer of the Works of the Vistula, backed by that of the late M. Lieussou, Hydrographical Engineer to the Imperial Marine of France, endorsed by M. Renaud, Inspector-General and member of the Council for Ponts et Chaussées of France, and supported by M. Rigault de Genouilly, Rear-Admiral of the Imperial Marine of France, and Captain Taurès, of the Imperial Marine, and member of the Council of the Admiralty of France, will, I think, in the opinion of this impartial tribunal, be considered sufficient to induce you to pause ere you surrender judgment to the views entertained by Mr. Stephenson, in opposition to those shared by the eminent engineers I have mentioned.

"The opinions of the late Mr. Rendel and Mr. Mc'Clean are opposed to Mr. Robert Stephenson's plan.

"Messrs. Rendel and Mc'Clean proposed to construct a ship canal in nearly a direct line between Suez and Port Said. The level of top-water throughout the whole length (93 miles) to be 23 feet above low-water of the Mediterranean Sea. The embankment to be carried into the deep water of the sea at each extremity, so as to avoid the necessity of dredging, and the locks to be constructed similar to the sea lock of the Caledonian Canal. Mr. George Rennie considers the cutting of the canal, as proposed by the engineers of the International Commission, perfectly practicable. It will therefore be seen that there exists in this country a great variety of opinion as to the precise mode in which the cutting should be effected.

"Captain Pim alluded in his paper to the great mortality caused by the making of the Mahmoudieh Canal, with what I considered questionable policy, seeing that if the argument holds good against the canal, it must necessarily do so with equal force against his own plan for a railway; but lest the example he has so prominently brought forward should cause the construction of canals or railways in Egypt to be viewed with disfavour, I willingly, in our joint justification, come forward with a few facts which, I hope, will effectually tend to dispel the fears his paper may have engendered on these points, and I shall do so with reference to the *very* Mahmoudieh Canal in question.

"On the 10th of April, 1856, 115,000 men commenced the work of cleansing, and the canal was re-opened for navigation on the 5th of May. The cleansing of the great Mahmoudieh Canal has been accomplished in less than three weeks. For some time back it had been getting choked up with mud, and although the traffic upon it was extremely active, it was becoming somewhat difficult. It was reported that his Highness the Viceroy would appear personally on the scene of action; and the work, confided to almost innumerable multitudes, was carried through with marvellous rapidity. Nevertheless the canal is not under twenty leagues in length and very wide; but the work had been systematically apportioned, and each working party was allowed to withdraw as soon as the portion of the task assigned to it was completed. The food, moreover, was good, and all passed off for the best.

"There was no less than 3,000,000 of cubic metres of muddy sediment to remove from the bed of the canal, which used to form a carriage road, 10 metres in breadth, between Alexandria and the Nile. The work had to be completed in haste in order that the workmen might return to their villages and reap the harvest, which becomes ripe towards the end of April. The time to be taken up in the work was accordingly fixed at one month, and the number of workmen to be employed at 67,000. The governors of the various provinces, appreciating the necessity for saving time, supplied more than 100,000 workmen, who had to be prevented from working through the night.

"The work was completed in twenty-two days, notwithstanding the number of subterraneous springs, and the difficult nature of the material to be dealt with, and notwithstanding, moreover, the falling in of a considerable part of the walls of the canal. The great Mahmoudieh Canal may be looked upon as an entirely new work from its increased width and greater draught of water, and the excellent road running beside it.

"Although the task came quite unexpectedly, and the workmen toiled with ardour in the midst of water and mud, the number of sick did not amount to more than five in a thousand, and the workmen were always well supplied with necessaries, a circumstance which forms a striking contrast with what occurred at the first digging of the canal, when more than 20,000 men perished through the deficiency of provisions, water, and proper tools, and the unskilful distribution of the work.

"The Fellahs possess a positive talent for all descriptions of earthwork; for

centuries past they have displayed this peculiar aptitude, and there is a good reason for it, for without canals Egypt would be nothing, and neglect of them would condemn her to barrenness, poverty, and famine. No Europeans could get through work of this description in such a climate. Although they are stronger and better skilled than the Fellahs, it is an undoubted and established fact that a European population could not continue to exist here; the first generation of foreign settlers manage to adapt themselves tolerably well at first, but they languish in the end, the second becomes very nearly exhausted, and the third dies out altogether. This is an incontestable fact.

"Captain Pim states 'that towards the Bay of Pelusium the depth of 25 feet of water extends for a distance of more than three miles from the shore. That the prevailing winds, exposure of the Bay of Pelusium, the lowness of the coast, and the absence of land-marks, increase the danger of navigation.'

"'That the quantity of alluvium carried by the easterly current in the Mediterranean, towards the Bay of Pelusium, would have the effect of choking up any harbour or channel which might be made.'

"Now I beg to observe that in 1857 the Commission of Engineers fixed the outlet of the canal at $28\frac{1}{2}$ kilometres (17 miles $6\frac{1}{2}$ furlongs) westward of the point adopted in the project; the shore being there less exposed to the prevailing winds, while it is steeper, and projects farther towards the open sea. Nearer to the N.W., in the Bay of Dibeh, and under the point of Damietta, a vessel could not right herself by a N.E. wind. Moreover, the length of the canal would be uselessly extended. The projection formed by the shore opposite Said, between the Bays of Pelusium and Dibeh, evidently offers the most favourable site; it will be easy to stand out, whatever wind is blowing, and a vessel caught suddenly in a gale of wind from the offing, at this part of the coast, can always right herself and get out into the open sea again.

"The local winds are extremely regular, and the anchorage on the coast of Egypt is better than any one to be found throughout the entire coast of Syria, which is directly exposed to the prevailing winds from the N.W., whereas the Egyptian coast is partially sheltered from them. The holding ground is everywhere excellent.

"M. Larousse, during his sojourn in the roadstead of the Bay of Pelusium, frequently observed the ship's position at intervals, and found no difference, although it had been blowing all night. If it were desired to bring a vessel to anchor previous to entering the canal, there would be no fear of her dragging her anchors. The native coasters declare that in rough weather they easily obtain shelter eastward of Damietta, in the very locality where the canal is to terminate. It should, moreover, be remarked, that previous to the establishment of Austrian and French companies for steam navigation, the coasting vessels engaged in what was called the Caravan Trade, on the coast of Egypt and Syria, frequently sought shelter in the western part of the Gulf of Pelusium. This is sufficient proof that these coasts are far from being so formidable as they were imagined to be in the absence of any positive knowledge of the facts; and it may be taken for certain that a vessel, sheltered from the W.N.W. winds, could keep her moorings with long cables during all weathers in water of 12 mètres (39 feet) depth.

"In farther confirmation of these facts, I beg to call the attention of the meeting to the report of Captain Philigret, entitled '*Observations Hydrographiques dans la Baie de Péluze*.' Captain Philigret was purposely stationed on board a corvette, belonging to his Highness the Viceroy of Egypt, during three of the worst months in the year, in the Bay of Pelusium, in order to ascertain the safety of this roadstead and make observations respecting the winds and currents.

"At Port Said the western or northern jetty would be 3500 mètres (3827 yards) long, in order to reach a depth of 10 mètres (32 feet). That on the

eastern or southern side would only be extended to a depth of 8·50 mètres (28 feet). Its length would be 2500 mètres (2734 yards). Their general direction will be from s.w. $\frac{1}{2}$ s. to n.e. $\frac{1}{2}$ n., and the extremity of one will be slightly deflected, so that the tangent of the two heads should lie exactly s.s.w. and n.n.e., and be exactly 1000 mètres in length (1093 $\frac{1}{2}$ yards).

"Subsequent investigations have, however, induced the engineers to dispense in a great measure with the length of these jetties, the nature of the sand being sufficiently firm to admit of dredging operations being successfully performed.

"By this means a sheltered roadstead, or outer port, would be formed, embracing a superficies of 40 hectares (98 acres), perfectly sheltered from the n.w. winds which prevail along this coast, and bring with them the greatest part of the storms. Vessels will be enabled to enter in all weathers, which is the essential point; and there will, besides, be a sort of inner road formed by the roadstead between the jetties. The length of this roadstead will be 1800 mètres (1968 $\frac{1}{2}$ yards), measuring from the extremity of the southern jetty, by 400 mètres (437 $\frac{1}{2}$ yards). This would form an additional space of 72 hectares (177 acres 3 roods), in which vessels would find shelter and smooth water.

"With regard to what Captain Pim states as to the mud of the Nile, I have to say that is a question to which the attention of the engineers was directed with more than usual care. One fact is perfectly certain, no traces of mud are to be found along the shore, and the sand upon it is as pure as it is fine. This sand extends along the bottom, without any admixture, to a depth ranging from 8 to 9 mètres (26 to 29 $\frac{1}{2}$ feet). The mud does not commence until beyond this range, and it is only at a depth of 10 mètres (32 feet 8 inches) that pure mud is found, and from thence it stretches out to an indefinite distance in the depths of the Mediterranean. Though here and there a few patches of mud may occur at a less depth, they are of insignificant dimensions, not exceeding 10 to 15 mètres (32 to 49 feet) in diameter, and 0·25 to 0·40 mètres (10 to 15 inches) in thickness. Such deposits are recent and superficial, and have not been subjected to the effects of a storm; they are of purely accidental occurrence, and the first gale of wind from the north would entirely disperse them."

Eleventh Meeting, May 9th, 1859.

SIR RODERICK I. MURCHISON, PRESIDENT, in the Chair.

PRESENTATIONS.—*Capt. C. C. Chesney, R.E.; Capt. K. R. Murchison; Consul W. T. Pritchard; and E. Rawdon Power, Esq.; were presented upon their election.*

ELECTIONS.—*L. C. Bailey, R.N.; R. Fisher, M.D.; and John Reeve, Esqrs.; were elected Fellows.*

EXHIBITIONS.—Several Maps and Plans of fortified towns, &c., in Italy, presented by the Government of Rome; and Maps of United States Harbour Improvements on Lake Michigan; were exhibited.

The Papers read were:—

1. *Notes on the Lower Danube.* By MAJOR STOKES, R.E.

Communicated by CAPT. R. COLLINSON, R.N., F.R.G.S.

THE "lower" portion of the Danube begins at the Iron Gates, and has an entirely different character to that of its upper course. It